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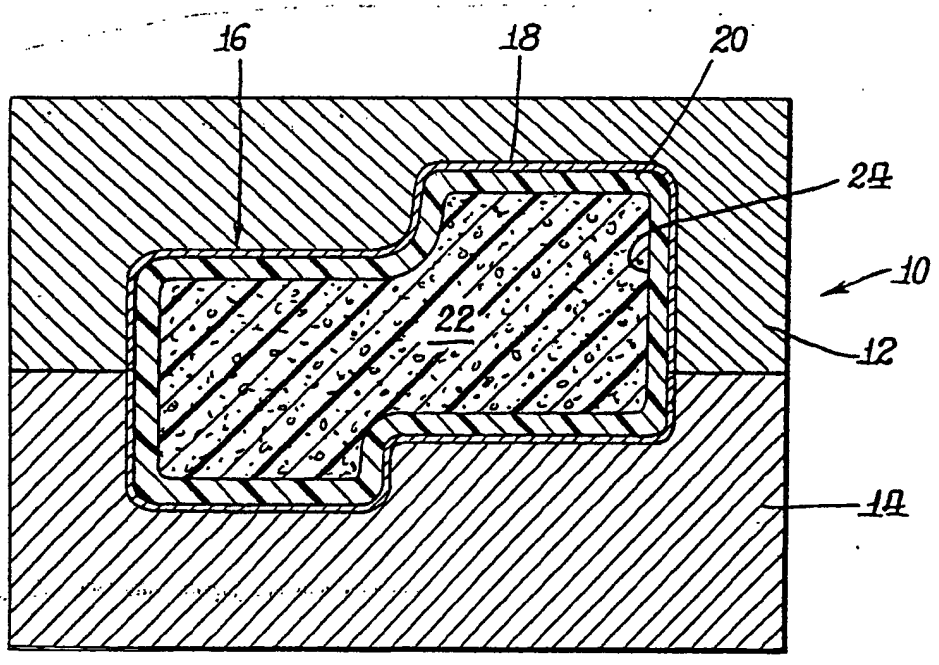
(54) Title: THIN SKIN LAMINATED STRUCTURE REINFORCED BY POLYMERIC FOAMS



(57) Abstract

A thin skin laminated composit structure is constructed by using a flexible open-celled foam (20) as a buffer material between the outer skin material (18) and the expandable thermoset polymeric foam (22) to produce a part having a smooth skin surface with better surface finish and with greater stiffness.

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THIN SKIN LAMINATED STRUCTURE REINFORCED BY POLYMERIC FOAMS

BACKGROUND OF THE INVENTION

One of the known methods of molding composite parts is to use the expansion casting system. The expansion casting system consists of filling the mold cavity with a polymeric foam material and a blowing agent which, when activated, foams the polymeric material to the shape of the mold cavity.

When the expansion casting technique is used in molding a part having a thin outer skin, the outer skin is often rippled due to the uneven expansion of the polymeric foams. As a consequence, the molded part is ruined or it is necessary to add a further finishing step to the molded part prior to painting in order to remove the unwanted surface irregularities from the outer skin surface. This additional finishing step adds to both the cost and time of producing the molded part.

SUMMARY OF THE INVENTION

This invention produces a smooth skin laminated structure using the foam casting technique by interposing a flexible open-celled foam wetted with a thermoset resin between the outer thin skin and an expandable thermoset polymeric foam. The polymeric foam, as it expands in the interior of the mold, comprises the inner surface of the flexible foam. The resin in the flexible foam cures after the expanded foam cures. The flexible foam compresses differentially in proportion to the uneven expansion of the

expandable foam and thereby prevents any distortion of the outer thin skin.

DESCRIPTION OF THE DRAWING

For a better understanding of this invention, reference may be made to the accompanying drawing in which:

FIGURE 1 is a cross-sectional view of a closed mold in which a thin skinned laminated structure is cast by means of an expandable polymeric foam in accordance with the principles of this invention; and

FIGURE 2 is another embodiment in which the principles of this invention are used to reinforce a thin skin body portion.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Figure 1, there is shown a mold 10 having an upper part 12 and lower part 14 and a cavity 16 of a desired pattern shape.

Following the principles of this invention, the first step is to lay up along the surface of the cavity 16 a thin sheet of material 18. The thin sheet 18 could be made of any plyable material such as metal, wood or fibrous reinforced material. The thickness of this sheet of material depends on the particular material employed, for example: .020 inches for aluminum, .1 inch for wood veneer, and .040 inch for fiber glass laminates. In any event, this thin sheet of material would be of a thickness that causes the skin to buckle upon an expandable polymeric foam being introduced into the cavity 16, which when activated expands outwardly and compresses against sheet 18.

The next step is to lay up onto the thin sheet 18, a sheet of flexible open-celled foam 20. Prior to insertion into the cavity 16, the open-celled foam sheet 20 is impregnated with a resinous material.

The flexible foam may be any of the commercially available material such as flexible polyurethane, sponge rubber, cellulose foams, etc. Its impregnation is prefer-

ably performed in a manner that the open cells of the foam are left coated with the thin film of a settable resin. A suitable technique for accomplishing this objective is described in my U.S. patent No. 3,269,887.

Finally, an expandable polymeric foam mixed with a chemical blowing agent 22 is inserted into the cavity 16. The quantity of this mixture must be sufficient to permit the polymeric foam to expand when activated to fill the volume defined by the inner walls of the flexible foam layer 20.

When the chemical blowing agent is activated, it expands the polymeric foam outwardly until it contacts and compresses the flexible foam. The flexible foam's inner surface 24 compresses differentially, in proportion to the uneven pressure applied by the gases of the expanding foam 22.

From the foregoing description it will be appreciated that the flexible foam layer 20 acts as a buffer zone between the expandable polymeric foam 22 and the thin skin layer 18 by absorbing the uneven expansion of the gaseous blowing agent. Due to this uneven expansion of the blowing agent, the impression in the inner surface of the open cell flexible foam 20 will vary around the perimeter of the mold cavity 16, but the pressure applied to the outer skin layer 18 will be negligible around the mold cavity perimeter.

It will be appreciated that the resin used to wet the flexible foam sheet 20 must be compatible with the polymeric foam mixture 22. For example, an epoxy resin and an amine curing agent would be suitable for wetting the flexible foam 20 when using a polyurethane rigid foam mixture as the expandable polymeric foam material. It is important that the settable resin cures after the expandable foam cures.

When cured, the settable resin bonds the thin skin 18 to the rigidized flexible foam 20.

SECOND EMBODIMENT

The principles of this invention can be used to add impact resistance to vehicular bodies or other struc-

tural members in those areas most subject to damage. For example, one of the areas of an automobile body subject to great damage upon a collision with the passenger compartment of the automobile is the hollow portion extending along the bottom of the door sill. As will now be explained, this invention permits this hollow portion to be reinforced by use of polymeric foam techniques without the undesirable side effect of crumpling the outer skin of the automotive body in that area.

Referring to Figure 2 there is shown a cross-section of a portion of an automobile body comprising the floor 50 and bottom of door sill 52. The bottom wall 52 of the door sill is constructed of a thin skin which may be metallic, plastic composite, or the like, and which extends the length of the door to define a generally U-shaped interior channel 54. To add structural reinforcement to the U-shaped floor member 52, a flexible open-celled foam 56 wetted with a settable resin is layed up along the interior walls 58 of the U-shaped channel 54. This flexible foam 56 would be wetted in a manner described with reference to Figure 1 to provide the flexible foam's open cells with the thin coating of settable resin. An expandable polymeric foam 60 in sufficient quantities to fill the U-shaped channel 54 when expanded is then added to the interior of the channel mixed with a chemical blowing agent. The bottom portion of the U-shaped channel 54 is left open to permit any excess of the expandable foam to pass through it.

The chemical blowing agent is activated to cause the polymeric foam 60 to expand outwardly toward the flexible foam 56. Upon contact, the inner surface 62 of the flexible foam compresses and applies a resultant negligible pressure outwardly against the thin skin wall members 52. The excess 64 of the expandable foam pushes through the open bottom of U-shaped channel 54.

As before, the settable resin in the flexible foam is selected to cure after the polymeric foam has cured. The resulting structure is a high impact resistant laminated structure which is reinforced by the expanded polymeric foam.

What is claimed is:

1. A thin skin laminated structure reinforced by polymeric foam comprising a rigid laminated body including an outer thin skin of a desired shape and including a flexible open-celled foam bonded to the back surface of said outer thin skin by a layer of cured resin impregnated into said open-celled foam and the inner surface of said cured flexible foam being differentially compressed by an irregular shaped cured expanded polymeric foam that fills the interior area defined by said inner surface of said cured flexible foam.

2. A thin skin laminated structure as defined in Claim 1, wherein said outer skin is aluminum of a thickness no greater than .020 inches.

3. A thin skin laminated structure as defined in Claim I, wherein said outer skin is a fiber reinforced sheet of a thickness no greater than .040 inches.

4. A thin skin laminated structure as defined in Claim 1, wherein said flexible open-celled foam is polyurethane.

5. A thin skin laminated structure as defined in Claim 1, wherein said settable resin is an epoxy resin.

6. A thin skin laminated structure as defined in Claim 6, wherein said polymeric foam is an expandable polyurethane foam.

7. A method for making a thin skin laminated structure reinforced by expansion casting of thermoset polymeric foams comprising the steps of:

a) placing a thin sheet of a skin material onto the interior surface of a mold cavity;

b) placing a sheet of flexible open-celled foam adjacent said thin skin sheet, said foam sheet having its cells coated with a settable resin and a curing agent;

c) inserting an expandable thermoset polymeric foam containing a chemical blowing agent into the interior of said mold cavity in sufficient quantity to fill when expanded the interior volume defined by the inner surfaces of said flexible foam sheet;

d) activating said blowing agent to cause the expansion of said polymeric foam into said flexible open-celled foam sheet and to compress said inner surface of said flexible sheet differentially in proportion to the uneven expansion of said expandable foam; and

e) effecting the cure of said settable resin after the cure of said polymeric foam.

8. A method as defined in Claim 7, wherein said thin skin material comprises a thin layer of a fibrous reinforcing material.

9. A method as defined in Claim 7, wherein said open-cell flexible foam is polyurethane.

10. A method as defined in Claim 7, wherein said settable resin is an epoxy resin.

11. A method as defined in Claim 7, wherein said polymeric foam is a polyurethane foam.

12. A method for making a thin skin laminated structure reinforced by expansion casting of polymeric foams comprising the steps of:

a) forming and maintaining a thin sheet of skin material into a particular shaped body;

b) placing a sheet of flexible open-celled foam adjacent the interior wall members of said body, the cells of said open-celled foam being coated with a settable resin and a curing agent;

c) inserting an expandable thermoset polymeric foam containing a chemical blowing agent into said body in

sufficient quantity to fill when expanded the interior volume defined by the inner surface of said flexible foam sheet;

d) activating said blowing agent to cause the expansion of said polymeric foam into said flexible open-celled foam sheet and to compress the inner surface of said flexible sheet differentially in proportion to the uneven expansion of said polymeric foam; and

e) effecting the cure of said settable resin after said polymeric foam has cured.

13. A method as defined in Claim 12, where said thin skin material comprises a thin layer of a fibrous reinforcing material.

14. A method as defined in Claim 12, wherein said open-cell flexible foam is polyurethane.

15. A method as defined in Claim 12, wherein said settable resin is an epoxy resin.

16. A method as defined in Claim 12, wherein said polymeric foam is a polyurethane foam.

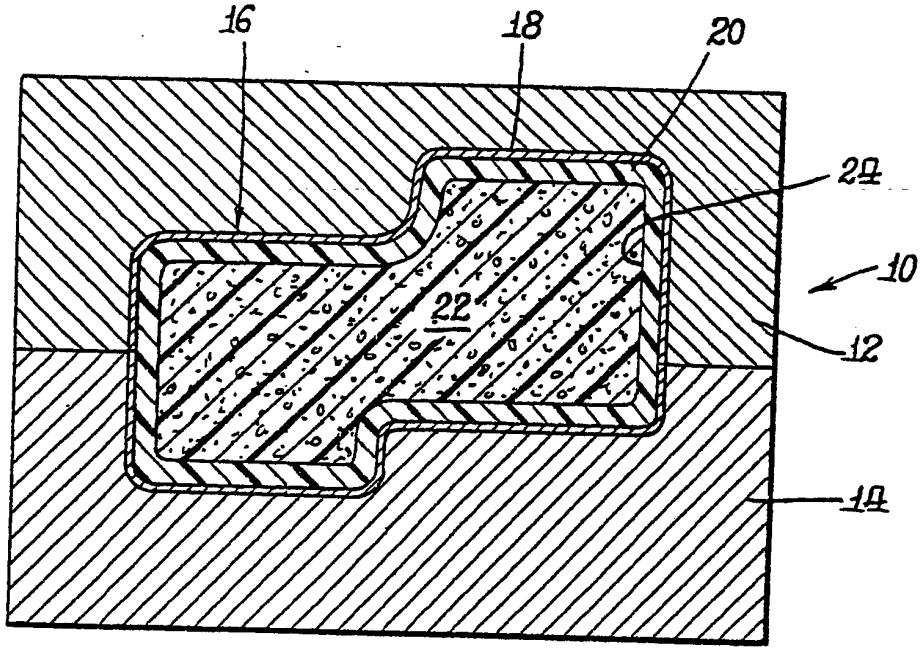

Fig. 1.

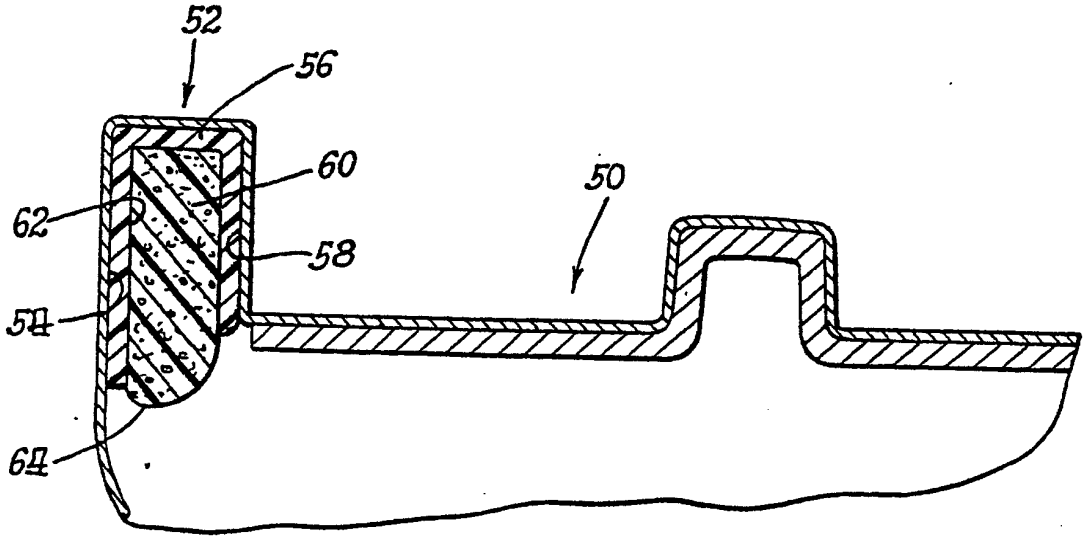

Fig. 2.

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 80/00225

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl.[3] B32B 5/18, B32B 27/40
U.S. Cl. 428/311

WO 80/01892

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	156/245; 264/45.1, 45.4, 46.4, 46.6, 54, 321 428/301, 310, 311, 315, 320, 414-416, 423.1, 423.3, 457

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
A	US, A, 3,118,153, Published 21 JANUARY 1964 HOOD	1-6
X	US, A, 3,193,598, Published 06 JULY 1965 SCHAFER	7-16
X	US, A, 3,269,887, Published 30 AUGUST 1966 WINDECKER	1-16
A	US, A, 3,437,551, Published 08 APRIL 1969 MARSHACK	1-6
A	US, A, 3,649,325, Published 14 MARCH 1972 AFFELT	1-6
X	US, A, 3,664,976, Published 23 MAY 1972 EVANS ET AL.	1-16
A	US, A, 3,698,927, Published 17 OCTOBER 1972 SAWYER	1-6
A	US, A, 3,795,722, Published 05 MARCH 1974 SASSAMAN	1-16
X	US, A, 3,873,407, Published 25 MARCH 1975 KUMATA ET AL.	1-6
X	US, A, 3,946,095, Published 23 MARCH 1976 DZIULAK	7-16
X	US, A, 3,989,781, Published 02 NOVEMBER 1976 CHANT	1-16
A	US, A, 4,017,656, Published 12 APRIL 1977 LASMAN ET AL.	1-6
A	US, A, 4,073,998, Published 14 FEBRUARY 1978 O'CONNOR	1-6

* Special categories of cited documents: [15]

"A" document defining the general state of the art

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IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
15 MAY 1980	18 JUN 1980
International Searching Authority [1]	**Signature of Authorized Officer [20]**
ISA/US	HAROLD ANSHER